4. Noise Covariance Matrices

Noise Covariance Matrices

Claim Term	CMU's Construction	Marvell's Construction
noise covariance matrices '839 Patent Claims 11, 16, 19, 23 '180 Patent Claim 6	noise statistics used to calculate the 'correlation-sensitive branch metrics.' CMU Brf. at 27	covariance matrices of signal samples (where the signal samples include noise). Marvell Brf. at 27-32

- The Dispute
  - Does "noise covariance matrices" have its ordinary meaning (Marvell) or has it been re-defined in the patent (CMU)?

Claim Language

- “noise covariance matrices” used to calculate “correlation sensitive branch metrics”

6. A method of detecting a sequence that exploits a correlation between adjacent signal samples for adaptively detecting a sequence of symbols through a communications channel having intersymbol interference, comprising:

(a) performing sequence detection on a plurality of signal samples using a plurality of correlation sensitive branch metrics;

(b) outputting a delayed decision on a transmitted symbol;

(c) outputting a delayed signal sample;

(d) adaptively updating a plurality of noise covariance matrices in response to the delayed signal samples and the delayed decisions;

(e) recalculating the plurality of correlation sensitive branch metrics from the noise covariance matrices using subsequent signal samples; and

(f) repeating steps (a)–(e) for every new signal sample.

See ’839 Patent Claims 11, 16, 19, 23; ’180 Patent Claim 6

Specification

- Covariance Matrix C_i used in Correlation-Sensitive Branch Metric Calculation:

With this notation, the general correlation-sensitive metric is:

$$M_i = \log det \frac{C_i}{det\ c_i} + \underline{N}_i^T C_i^{-1} \underline{N}_i - \underline{n}_i^T c_i^{-1} \underline{n}_i \quad (13)$$

'839 Patent 6:66-7:3

As stated above, the covariance matrix is given as:

$$C_i = \begin{bmatrix} \alpha_i & \underline{c}_i \\ \underline{c}_i^T & c_i \end{bmatrix}. \quad (14)$$

'839 Patent 7:25-29

$$\hat{C}'(\ominus, +, -) = \beta \hat{C}(\ominus, +, -) + (1-\beta)\underline{N}\ \underline{N}^T \quad (26)$$

$$= \begin{bmatrix} 0.4755 & -0.189 \\ -0.189 & 0.7620 \end{bmatrix}$$

The matrix $\hat{C}'(\ominus, +, -)$ becomes our estimate for the covariance matrix corresponding to this particular symbol sequence (trellis path) and is used to compute the metrics (13) in the subsequent steps of the Viterbi-like algorithm.

'839 Patent 11:1-10

Specification

- First reference to "the noise covariance matrices"
- Implies the ordinary definition

SUMMARY OF THE INVENTION

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Because the noise statistics are non-stationary, the noise sensitive branch metrics are adaptively computed by estimating the noise covariance matrices from the read-back data. These covariance matrices are different for each branch of the tree/trellis due to the signal dependent structure of the media noise. Because the channel characteristics in magnetic recording vary from track to track, these matrices are tracked on-the-fly, recursively using past samples and previously made detector decisions.

'839 patent 2:15-23

CMU's "i.e." Argument Fails

- CMU argues: "By using the abbreviation '*i.e.*,' Latin for 'that is,' the CMU patents equated the term 'noise covariance matrices' with 'noise statistics.'"

CMU Brf. at 28

- Fails for Two Reasons:

1. English Usage: "*i.e.*, like *that is*, typically introduces a rewording or clarification of a statement that has just been made or of a word that has just been used"

Webster's Dictionary of English Usage (1989) (Surreply Exh. 1)

   - example: "to update my contact information, *i.e.* to update my address"
   - "the adaptive nature, i.e., the data dependent nature, of the circuit 52"

'839 Patent 8:9-10

2. Federal Circuit: "when read in the context of the entire [ ] patent, the reference to 'saccharides (i.e., sugars)' <u>does not constitute a definition</u> of 'saccharides.'"

Pfizer, Inc. v. Teva Pharmaceuticals, USA, Inc., 429 F.3d 1364 (Fed. Cir. 2005).

CMU's "i.e." Argument Fails

- CMU reads out "covariance matrices" by reading in redundant language ("correlation-sensitive branch metrics")

6. A method of detecting a sequence that exploits a correlation between adjacent signal samples for adaptively detecting a sequence of symbols through a communications channel having intersymbol interference, comprising:

(a) performing sequence detection on a plurality of signal samples using a plurality of correlation sensitive branch metrics;

(b) outputti ... ymbol;

(c) outputting a delayed signal sample;

(d) adaptively updating a plurality of noise covariance matrices in response to the delayed signal samples and the delayed decisions;

(e) recalculating the plurality of correlation sensitive branch metrics from the noise ~~covariance matrices~~ using subsequent signal samples; and

(f) repeating steps (a)–(e) for every new signal sample.

statistics used to calculate the correlation-sensitive branch metrics

See '839 Patent Claims 11, 16, 19, 23; '180 Patent Claim 6

CMU's "i.e." Argument Fails

- Re-defining "noise covariance matrices" as "noise statistics" removes "covariance" and "covariance matrices" from the claims
  - "[a] claim construction that gives meaning to all the terms of the claim is preferred over one that does not do so."

    Merck & Co., Inc. v. Teva Pharm. USA, Inc., 395 F.3d 1364, 1372 (Fed. Cir. 2005).
  - "covariance" and "covariance matrices" have well-known meanings in engineering and statistics
  - "covariance" and "covariance matrices" are used independently in other claims

    See '839 Patent Claim 10.

CMU's "i.e." Argument Fails

- Patents use "noise covariance matrices" separately from "noise statistics"

> Because the noise statistics are non-stationary, the noise sensitive branch metrics are adaptively computed by estimating the noise covariance matrices from the read-back data. These covariance matrices are different for each branch of the tree/trellis due to the signal dependent structure of the media noise. Because the channel characteristics in mag-

'839 Patent 2:15-23

> Computing the branch metrics in (10) or (13) requires knowledge of the signal statistics. These statistics are the mean signal values m_i in (12) as well as the covariance matrices C_i in (13). In magnetic recording systems, these

'839 Patent 8:24-27

CMU's "i.e." Argument Fails

- "noise statistics": used by all branch metrics
- "covariance matrices": used by only "correlation-sensitive branch metric"

Specific expressions for the branch metrics that result under different assumptions on the noise statistics are next considered.

'839 Patent 5:56-58

Variance dependent branch metric.

$$M_i = \log\sigma_i^2 + \frac{N_i^2}{\sigma_i^2} = \log\sigma_i^2 + \frac{(r_i - m_i)^2}{\sigma_i^2} \quad (10)$$

'839 Patent 6:15-34

With this notation, the general correlation-sensitive metric is:

$$M_i = \log\, det\frac{C_i}{det\ \ c_i} + \underline{N}_i^T C_i^{-1} \underline{N}_i - \underline{n}_i^T c_i^{-1} \underline{n}_i \quad (13)$$

'839 Patent 6:66-7:4

CMU's "All Embodiments" Argument Fails

- CMU: "Marvell's proposed construction improperly narrows the claims so that they do not encompass all embodiments disclosed in the patents that use 'noise covariance matrices' to compute the correlation-sensitive branch metric."

  CMU Brf. at 31

- Fails for two reasons:
  1. "[A] claim need not cover all embodiments."

     Intamin v. Magnetar, 483 F.3d at 1337 (Fed. Cir. 2007)

  2. Marvell's construction covers all of the embodiments that use covariance matrices

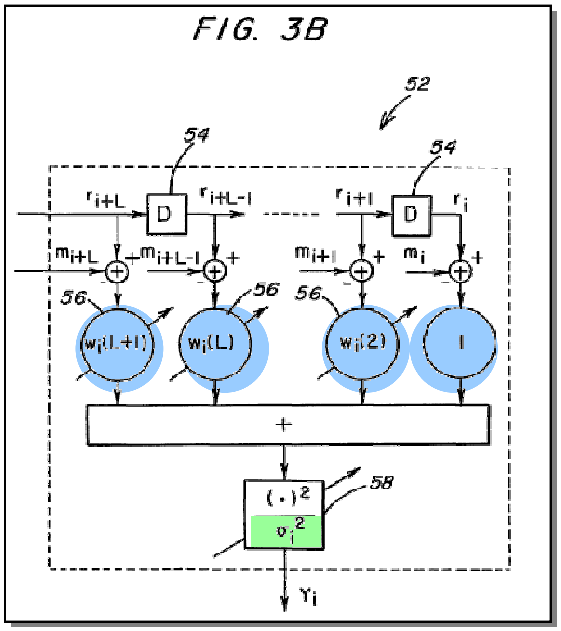
CMU's "All Embodiments" Argument Fails

- CMU: "Specifically, Marvell's construction excludes the tapped-delay line FIR filter embodiment of Figure 3B"

CMU Brf. at 31

  - "In this embodiment, the noise statistics used to calculate the branch metrics are the variance σ^2 and the vector of weights w_i."

McLaughlin Decl. (CMU) at ¶ 18



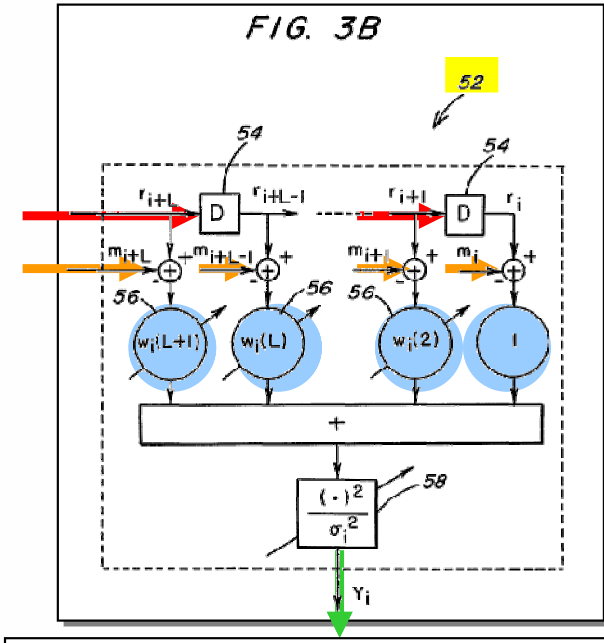
the data dependent nature, of the circuit **52**. The weights $\underline{w}_i$ and the value $\sigma_i^{\ 2}$ can be adapted using three methods. First, $\underline{w}_i$ and $\sigma_i^{\ 2}$ can be obtained directly from Equations (20) and (16), respectively, once an estimate of the signal-dependent covariance matrix C_i is available. Second, $\underline{w}_i$ and σ_i^2 can be calculated by performing a Cholesky factorization on the inverse of the covariance matrix C_i. For example, in the $L_iD_i^{-1}L_i^T$ Cholesky factorization, $\underline{w}_i$ is the first column of the Cholesky factor L_i and $\sigma_i^{\ 2}$ is the first element of the diagonal matrix D_i. Third, $\underline{w}_i$ and $\sigma_i^{\ 2}$ can be computed directly from the data using a recursive least squares-type algorithm. In the first two methods, an estimate of the covariance matrix is obtained by a recursive least squares algorithm.

'839 Patent 8:10-23

  - The patent describes three methods for calculating σ^2 and w_i
  - Marvell's construction covers "the first two methods" (which are the only embodiments described using covariance matrices)

CMU's "All Embodiments" Argument Fails

- The third method (no covariance matrix) corresponds to claims that calculate a "weight w_i" (Group III Claims)
  - These claims do not use "noise covariance matrices"



Equations (17), (18) and (16) (the circuit **52**) can be implemented as a tapped-delay line as illustrated in FIG. 3B. The

'839 Patent 7:61-62

20. A branch metric computation circuit for generating a branch weight for branches of a trellis for a Viterbi-like detector, wherein the detector is used in a system having Gaussian noise, comprising:

a logarithmic circuit having for each branch an input responsive to a branch address and an output;

a plurality of arithmetic circuits each having a first input responsive to a plurality of signal samples, a second input responsive to a plurality of target response values, and an output, wherein each of the arithmetic circuits corresponds to each of the branches;

a sum circuit having for each branch a first input responsive to said output of said logarithmic circuit, a second ... nsive to said output of said arithmetic ... an output.

21. The circuit of claim **20** wherein said branch metric computation circuit is a tapped-delay line circuit with adaptive weight.

'839 Patent Claims 20-21